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ABSTRACT

These symposium papers discuss the instructional use of computers in psychology, with emphasis on computer-produced simulations. The first, by Rich Edwards, briefly outlines LABSIM, a general purpose system of FORTRAN programs which simulate data collection in more than a dozen experimental models in psychology and are designed to train students in content areas of psychology, research, decision making, analysis of data, and communication of findings. Douglas B. Eamon then describes the Moon Illusion, a LABSIM model designed to investigate why the moon appears larger on the horizon than at its zenith even though it remains at a relatively constant distance from the earth. Warren P. Street presents general methods and specific examples of how to produce computer simulations of empirical events that demonstrate principles covered in introductory statistics courses using MINITAB, a general-purpose, statistical FORTRAN program. General procedures are outlined with directions for advance preparation, execution of the demonstration, and saving of worksheets generated during simulation. MINITAB commands for simulation are listed, and specific directions for producing several different demonstration simulations are given. (LMM)

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COMPUTER SIMULATION IN UNDERGRADUATE INSTRUCTION: A SYMPOSIUM

Warren R. Street
Pete L. Trotter
Rich Edwards

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Computer Simulation in Undergraduate Instruction

Chair: Warren R. Street, Central Washington University
Pete L. Trotter, CONDUIT
Rich Edwards, Educational Software Systems

This symposium consists of three speakers addressing the topic of the instructional use of computers in psychology, with particular emphasis on computer-produced simulations of psychological experiments and simulations of the empirical demonstration of statistical principles. The first speaker will summarize the current state of the art in psychological instructional computing. Modelling and simulation will be placed in the broader context of computer-based instruction. Current patterns of computer use in psychology will be described along with prospects for future hardware and software development. The role of the microcomputer will receive special attention. Criteria for effective instructional programs will be explained.

The second speaker will describe and demonstrate LABSIM, a general purpose simulator of experiments in psychology. This program allows a student to simulate over a dozen experiments with a wide range of research design options available. Additional experiments may be added by any instructor. LABSIM is designed to train students in content areas of psychology, research decision-making, analysis of data, and communication of findings. Videotape of actual computer runs will be shown to demonstrate the use of LABSIM. The presentation will describe instructional uses of simulation, the advantages and disadvantages of simulation, and student skills required to run an experiment simulator.

The third speaker will present a method of simulating empirical demonstrations of statistical principles for statistics and experimental psychology classes. Through the use of MINITAB, a commonly available computerized statistics package, an instructor can store commands that will quickly produce demonstrations of complex statistical principles (e.g. the central limits theorum). Videotapes of actual simulation runs will be shown. Advantages and disadvantages of statistics simulations will be discussed and specific directions for producing several different simulations will be given.

Computers in Psychology Instruction: A Perspective from CONDUIT

The potential of computing as an instructional tool has been touted for many years. Has it lived up to its potential? How has it changed in the last twenty years? Are there changes on the horizon that will make an impact? These are some of the questions that will be addressed in this presentation.

In judging this proposal, it may be helpful to know more about CONDUIT. Located on the campus of the University of Iowa, CONDUIT is committed to the improvement of undergraduate instructional computing by being a reliable source of reviewed and documented instructional material, by continuing to research and develop the use of computers in instruction, and by being a source of information for users and authors. CONDUIT was founded in 1971 by a grant from the National Science Foundation and continues to be supported by the NSF, the Fund for the Improvement of Postsecondary Education, and sales of materials. It is a not-for-profit organization.

Part of the presentation will summarize current patterns of use. A major source of information will be the CONDUIT 1978 State of the Art Report of Instructional Computing, focusing on data gathered from psychology departments. The 1978 report will be compared with conclusions presented in CONDUIT's 1977 State of the Art Report. Currently available and soon to be announced materials will be described. Examples in modeling-simulation, experimentation, statistics, and computer-managed instruction will be presented.

The rest of presentation will concern the future of instructional computing in psychology and will review both hardware and software developments. Hardware emphasis will be on the impact and potential of microcomputers. Information from CONDUIT's current NSF project to study the microcomputer as an instructional tool will be referenced. Software materials currently being developed will be described along with a survey of topics or content areas for which software is still needed.

LABSIM: A Computer Simulator of Psychology Experiments

Rich Edwards
Educational Software Systems

This presentation will describe a general purpose system of FORTRAN programs called LABSIM which simulate the collection of data in over a dozen experimental models in psychology. LABSIM was originally written at Washington State University. Specific presentation topics will include a system description, required user skills, advantages of simulation, illustration of inputs and outputs, alternative classroom uses, program diagnostics, and available documentation.

LABSIM enables the student to rapidly design and conduct a large number of experiments to answer specific research questions in a variety of content areas. The underlying assumption of LABSIM is that to be a successful professional the student must (a) obtain knowledge within specific content areas, (b) master fundamentals of experimental methodology, (c) acquire skills in data reduction and analysis, and (d) be able to communicate research findings. LABSIM is designed to integrate these aspects of the research environment into undergraduate courses of instruction.

LABSIM is referred to as a general purpose system because all dependent variable scores, regardless of the experiment being simulated, are generated by a single multiple regression equation. Therefore, only the names of the variables, effects of the variables, and regression coefficients vary from one model to another. This feature allows the instructor to add new experiments without modification of existing routines.

Computer Simulations to Demonstrate Statistical Principles

Warren R. Street
Central Washington University

A psychology student's instruction in statistics often includes empirical demonstrations of statistical principles. Producing a binomial distribution be flipping coins is an example of such a demonstration. These demonstrations are valuable because they show that statistical abstractions have empirical foundations, but the demonstrations take a great deal of time, tend to be limited to small numbers in the data, small numbers of trials, and simple principles.

This presentation will show how computer-simulated empirical demonstrations can overcome some of these limitations. The speaker will explain and show examples of statistical simulations using MINITAB, a statistical package widely available on college and university computer systems. MINITAB has extensive data generation, sampling, and analysis capabilities. It also allows a user to store a series of commands, recall the stored series, and execute the series as many times as the user wishes. This repeated execution facility allows an instructor to store many demonstration routines and recall and execute them at will. MINITAB's capabilities make it possible to rapidly demonstrate complex principles using large numbers in the data and large sample sizes. For example, one can quickly perform 100 t-tests on two samples of 50 drawn from the same population of 2000 random numbers to demonstrate the Type I errors that will be made at the .10, .05, and .01 alpha levels.

The presentation will describe the characteristics of MINITAB, the general tactics of programming statistical demonstrations, and will present videotaped computer runs of sample simulations. A handout will detail the commands that produce each simulation. The speaker will describe simulations that demonstrate principles of probability, the law of large numbers, the central limits theorum, factors affecting correlation (e.g., deviant cases, restriction of range), the distribution of errors of prediction, and Type I and Type II errors. Advantages and disadvantages of simulation and the hardware needed for classroom demonstration will be discussed.

LABSIM

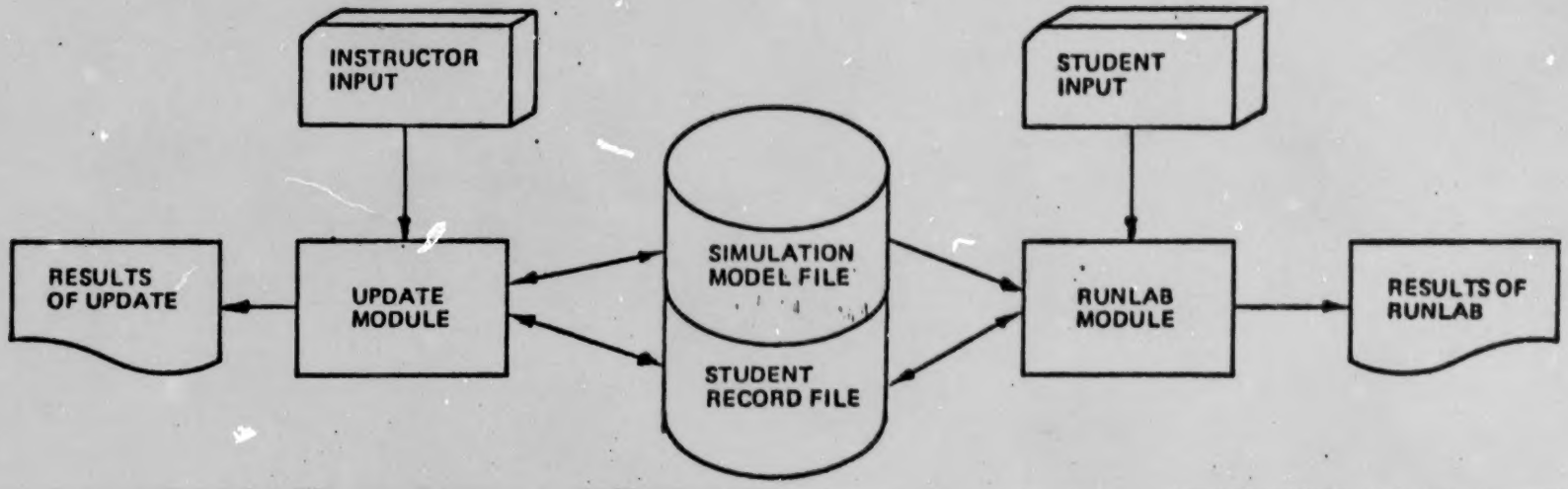
A GENERAL PURPOSE SIMULATION PROGRAM FOR TEACHING PRINCIPLES OF EXPERIMENTAL DESIGN AND DATA ANALYSIS

LABSIM / OBJECTIVE

TO INTEGRATE FOUR ASPECTS OF THE RESEARCH ENVIRONMENT

- KNOWLEDGE WITHIN SPECIFIC CONTENT AREAS
- FUNDAMENTALS OF EXPERIMENTAL METHODOLOGY
- DATA REDUCTION AND STATISTICAL ANALYSIS
- COMMUNICATION OF RESEARCH FINDINGS

LABSIM / SYSTEM DESCRIPTION



```
(A)          LABSIM - COMPUTER SIMULATION OF LABORATORY EXPERIMENTS
                        CENTRAL WASHINGTON UNIVERSITY
                        ELLENSBURG, WASHINGTON  98926

(B) ENTER THE CODE FOR THE FILE TO BE ACCESSED.
HELP

THE VALUES FOR THIS VARIABLE ARE
     1 = MODEL FILE
     2 = STUDENT FILE
(C) 2

ENTER THE CODE FOR THE TYPE OF UPDATE DESIRED.
(D) HELP

THE VALUES FOR THIS VARIABLE ARE
     1 = SPECIFY THE NUMBER OF STUDENTS AND MODELS
     2 = INITIALIZE ALL STUDENT RECORDS FOR ALL MODELS.
     3 = INITIALIZE ALL STUDENT RECORDS FOR 1 MODEL
     4 = INITIALIZE ALL STUDENT ACCOUNTS FOR 1 MODEL
     5 = INCREMENT ALL STUDENT ACCOUNTS FOR 1 MODEL
     6 = INCREMENT SELECTED STUDENT ACCOUNTS FOR SELECTED MODELS
     7 = PRINT ALL STUDENT RECORDS FOR ALL MODELS
     8 = PRINT ALL STUDENT RECORDS FOR 1 MODEL
     9 = PRINT SELECTED STUDENT RECORDS FOR ALL MODELS
    10 = PRINT SELECTED STUDENT RECORDS FOR SELECTED MODELS
1

ENTER THE NUMBER OF STUDENTS USING LABSIM AND THE NUMBER OF MODELS IN THE
MODEL FILE.
31 14

(E) SIMULATION ACTIVITY RECORDS WILL BE MAINTAINED FOR  31 STUDENTS IN 14
SIMULATION MODELS.


(F) ENTER ONE (1) IF YOU WANT TO SUBMIT ANOTHER UPDATE.
OTHERWISE ENTER A ZERO (0).
1
```

LABSIM / SPECIFICATION OF INITIAL CONDITIONS (CONT.)

```
ENTER THE CODE FOR THE FILE TO BE ACCESSED.
2

ENTER THE CODE FOR THE TYPE OF UPDATE DESIRED.
2

ENTER THE NUMBER OF DOLLARS TO BE PLACED IN EACH STUDENT ACCOUNT.
15000

ALL VARIABLES IN THE STUDENT RECORD FILE HAVE BEEN INITIALIZED TO ZERO FOR 31
STUDENTS IN EACH OF 14 SIMULATION MODELS.  ALL
STUDENT ACCOUNTS HAVE BEEN INITIALIZED TO $15000.00.
```

LABSIM / VERIFICATION OF MODEL VARIABLES

```
ENTER THE CODE FOR THE FILE TO BE ACCESSED.
1

ENTER THE CODE FOR THE TYPE OF UPDATE DESIRED.
2

ENTER THE NUMBER OF MODELS TO BE PRINTED.
1

ENTER THE IDENTIFICATION NUMBER OF THE 1 MODEL(S) TO BE PRINTED.
2
```

SIMULATION MODEL: 2

COMMUNICATION NETWORKS

NUMBER OF INDEPENDENT VARIABLES = 4
NUMBER OF SUBJECTS(GROUPS)/CONDITION = STUDENT SELECTS
MAXIMUM SUBJECTS(GROUPS)/CONDITION = 40
MINIMUM SUBJECTS(GROUPS)/CONDITION = 6
MAXIMUM REJECTION PERCENTAGE = 0
STATISTICAL ANALYSIS = F WITH PLOTS
ACCOUNTING SYSTEM = YES
NUMBER OF DEPENDENT VARIABLES = 2
COST/SUBJECT = $ 2.00
COST/REJECTED SUBJECT = $ 1.00
BONUS FOR SIGNIFICANT EFFECT = $100.00

INDEPENDENT VARIABLE 1 = COMPLEXITY

COST TO VARY OR CONTROL = $ 5.00
REPEATED MEASURES VARIABLE = YES
TYPE = DISCRETE
PARAMETER VALUE RANGE = 1 - 2
LEVELS = HIGH LOW
PROBABILITY VALUE = 0.50 1.00

DEPENDENT VARIABLE 1 = MEAN NUMBER OF MESSAGES REQUIRED TO SOLVE FOUR PROBLEMS

EFFECT = 2.00 1.00
LINE SEGMENTS = 1
REG. COEFFICIENTS = 0.00
DUMMY VARIABLE = NO

DEPENDENT VARIABLE 2 = MEAN RATING OF JOB SATISFACTION ON A 10-POINT SCALE

EFFECT = 0.00 0.00
LINE SEGMENTS = 1
REG. COEFFICIENTS = 0.00
DUMMY VARIABLE = YES

INDEPENDENT VARIABLE 2 = STRUCTURE

COST TO VARY OR CONTROL = $ 5.00
REPEATED MEASURES VARIABLE = YES
TYPE = DISCRETE
PARAMETER VALUE RANGE = 1 - 3
LEVELS = WHEEL CHAIN CIRCLE
PROBABILITY VALUE = 0.33 0.67 1.00

DEPENDENT VARIABLE 1 = MEAN NUMBER OF MESSAGES REQUIRED TO SOLVE FOUR PROBLEMS

EFFECT = 3.00 2.00 1.00
LINE SEGMENTS = 1
REG. COEFFICIENTS = -9.00
DUMMY VARIABLE = NO

```
     DEPENDENT VARIABLE 2      = MEAN RATING OF JOB SATISFACTION ON A 10-POINT SCALE
     ---------------------
          EFFECT               =     1.00        2.00        3.00
          LINE SEGMENTS        =     1
          REG. COEFFICIENTS    =       0.00
          DUMMY VARIABLE       = NO

INDEPENDENT VARIABLE  3 = SEX OF SUBJECT
-----------------------
     COST TO VARY OR CONTROL   = $  2.00
     REPEATED MEASURES VARIABLE = NO
     TYPE                      = DISCRETE
     PARAMETER VALUE RANGE     =     1 -      2
     LEVELS                    = MALE                    FEMALE
     PROBABILITY VALUE         = 0.50  1.00

     DEPENDENT VARIABLE 1      = MEAN NUMBER OF MESSAGES REQUIRED TO SOLVE FOUR PROBLEMS
     ---------------------
          EFFECT               =     0.00        0.00
          LINE SEGMENTS        =     1
          REG. COEFFICIENTS    =       0.00
          DUMMY VARIABLE       = YES

     DEPENDENT VARIABLE 2      = MEAN RATING OF JOB SATISFACTION ON A 10-POINT SCALE
     ---------------------
          EFFECT               =     0.00        0.00
          LINE SEGMENTS        =     1
          REG. COEFFICIENTS    =       0.00
          DUMMY VARIABLE       = YES

INDEPENDENT VARIABLE  4 = SUBMISSIVENESS
-----------------------
     COST TO VARY OR CONTROL   = $ 10.00
     REPEATED MEASURES VARIABLE = NO
     TYPE                      = DISCRETE
     PARAMETER VALUE RANGE     =     1 -      2
     LEVELS                    = HIGH                    LOW
     PROBABILITY VALUE         = 0.50  1.00

     DEPENDENT VARIABLE 1      = MEAN NUMBER OF MESSAGES REQUIRED TO SOLVE FOUR PROBLEMS
     ---------------------
          EFFECT               =     0.00        0.00
          LINE SEGMENTS        =     1
          REG. COEFFICIENTS    =       0.00
          DUMMY VARIABLE       = YES

     DEPENDENT VARIABLE 2      = MEAN RATING OF JOB SATISFACTION ON A 10-POINT SCALE
     ---------------------
          EFFECT               =     1.00        2.00
          LINE SEGMENTS        =     1
          REG. COEFFICIENTS    =      -6.00
          DUMMY VARIABLE       = NO
```

DEPENDENT VARIABLE 1 = MEAN NUMBER OF MESSAGES REQUIRED TO SOLVE FOUR PROBLEMS

TWO-WAY INTERACTIONS			
INDEPENDENT VARIABLES	=	1 2	
REGRESSION COEFFICIENTS	=	6.00	
ERROR MEAN	=	16.00	
ERROR STANDARD DEVIATION	=	3.00	
BOUNDS ON VALUE OF DV	=	8.00	50.00
DIGITS TO RIGHT OF DECIMAL	=	2	
DV BASED ON	=	GROUPS OF SUBJECTS	

DEPENDENT VARIABLE 2 = MEAN RATING OF JOB SATISFACTION ON A 10-POINT SCALE

TWO-WAY INTERACTIONS			
INDEPENDENT VARIABLES	=	2 4	
REGRESSION COEFFICIENTS	=	1.00	
ERROR MEAN	=	12.00	
ERROR STANDARD DEVIATION	=	0.75	
BOUNDS ON VALUE OF DV	=	0.00	10.00
DIGITS TO RIGHT OF DECIMAL	=	2	
DV BASED ON	=	GROUPS OF SUBJECTS	

The Moon Illusion

A LABISM Model

by

Douglas B. Eamon
Department of Psychology
Albion College
Albion, Michigan 49224

Introduction

Philosophers, scientists and lovers have observed since the beginning of history that the moon appears to be larger on the horizon than at its zenith. It is known that the moon remains at a relatively constant distance from the earth, and surely does not change size, so why does this phenomenon occur?

One might suggest, as did the author's high school science teacher, that the differences in the refraction of the atmosphere might be the cause. But enlargement of an object would require that the refraction be in different directions, such as with the lens of a telescope. Further, if one photographs the moon, and then measures the diameter of the photographic image, there is no difference between the size of the image at the horizon as compared to the image at the zenith. Thus, the same sized retinal image (the portion of the retina upon which the image of the object falls) gives rise to quite different perceptual experiences of size. By definition, this phenomenon is a visual illusion.

A number of plausible explanations for the illusion have been suggested. For example, it has been proposed that, since the illusion depends on differences in perceived direction (straight ahead versus up), the position of the eyes in the head might be causally related to it. The position of the eyes relative to the object viewed is known as the "angle of regard." The angle of regard can be varied independently of the position of the moon on the horizon or at the zenith by having a subject view it either standing up or supine (lying down). Thus, the moon could be viewed straight on (eyes level) at its zenith simply by having the subject lie down while looking at it. Similarly, if his/her head were toward the moon on the horizon, raising the eyes would, under this hypothesis, produce the same effect (no size illusion) as viewing the zenith moon while standing up.

For other sorts of hypotheses, more ingenious methods of testing must be devised. Artificial moons (paper disks glued to a glass surface) in a special apparatus might be used not only to test variations on the angle of regard notion, but to test effects of factors such as presence or absence of terrain, distance of the horizon from the viewer, amount of cloudiness, etc.

In this simulation you will have the opportunity to examine several possible causes for the moon illusion. Try to discover which variable (and which level of that variable) produces the greatest amount of illusion as measured by the dependent variable. You will find the references cited at the end will save you much time in selecting your independent variables and their levels.

Apparatus

An apparatus devised by Kaufman and Rock (1962) will be used in all of these experiments. This device incorporates a half-silvered "combining glass" through which the subject looks out at the sky, and upon which images of moons can be projected. In order to make the image appear luminous, a light is shined through a circular hole (aperture) and onto the combining glass (rather than gluing paper disks to the glass).

Two identical units of this type are available, one of which may be used for creating an image of the zenith moon and the other for creating an image of the horizon moon.

Procedure

Subjects will first be shown an image of the moon (either horizon or zenith) and told that it is the "standard" from which they should form an impression of size. Afterwards, they will be shown a series of comparison moons varying in size from very much smaller than the standard to very much larger than the standard. They will be instructed to state when the apparent sizes of the comparison moons and the standard moon are equal. The dependent variable will be the ratio of the diameters of the standard and comparison moons that are judged to be of equal size.

You may manipulate or control any of the following potential independent variables. Note that these are all manipulations of the comparison moon image.

Potential Independent Variables

1. Sky Position. The image of the comparison moon may be seen either on the horizon or at its zenith. (See the description of the dependent variable.)

Code	Sky Position
0	Uncontrolled
1	Horizon
2	Zenith

2. Background. An important variable in this experiment may be whether terrain is present or absent. By inserting a prism into the viewing apparatus, you may project a moon in either a horizon or zenith sky position onto a background which includes terrain, or one which does not include terrain.

Code	Background
0	Uncontrolled
1	Terrain
2	No Terrain

3. Terrain Orientation. An inverting lens may be inserted into the apparatus which will invert the terrain, if you have included terrain. If no terrain is present, this variable will have no effect.

Code	Terrain Orientation
0	Uncontrolled
1	Normal
2	Inverted

4. Cloudiness. You may run your subjects on totally clear days, days with broken cloud coverage (between 30% and 70% coverage), or totally overcast days. If this variable is left uncontrolled, all subjects will be run on clear days.

Code	Cloudiness
0	Uncontrolled
1	Clear
2	Broken
3	Overcast

5. Horizon Distance. The distance of the horizon from the viewer may be varied. In the near condition, the horizon will be obscured by trees and shrubbery at about 2000 feet; in the far condition it will be about two miles from the observer.

Code	Horizon Distance
0	Uncontrolled
1	Near
2	Far

6. Viewing Condition. Subjects may use either both eyes (binocular) in viewing the images, or may be restricted to using only one eye (monocular).

Code	Viewing Condition
0	Uncontrolled
1	Monocular
2	Binocular

7. Angle of Regard. As discussed in the Introduction, the angle at which the image is viewed may be an important variable. In your experiment, angle of regard will be manipulated by adjusting the viewing apparatus so that subjects will view the moon image either with their eyes raised (looking up, as if the moon were at its zenith) or eyes level (looking straight ahead). Notice that the actual position of the moon image (up or straight ahead) need not correspond to the manner in which the subject views it.

Code	Angle of Regard
0	Uncontrolled
1	Eyes Level
2	Eyes Raised

8. Color. Because the atmosphere scatters certain wavelengths of the light passing through it, the horizon moon often appears to be reddish in color as compared to the zenith moon. Perhaps the color itself accounts for the moon illusion. Four possible colors may be tested by inserting filters into the apparatus. (If you leave this variable uncontrolled, all subjects will be tested under "white" color conditions.

Code	Color
0	Uncontrolled
1	Red
2	Blue
3	Green
4	White

9. Brightness. The full moon rises over the horizon at sunset, when the light from the sun brightens the sky, while the zenith moon occurs later in the evening, when the sun's light has gone. When compared to its background, then, the horizon moon may appear less luminous than the zenith moon, which is viewed against the dark sky. You may manipulate or control this variable by inserting various lenses into the apparatus. Brightness may range from zero (completely dark) to three (similar to early evening light--brighter than sunset). If this variable is left uncontrolled, zero brightness will be assumed for all subjects.

Code	Brightness
0	Uncontrolled
1	Zero
2	One
3	Two
4	Three

Dependent Variable

The dependent variable for this experiment is the ratio of the diameters of the apertures through which light is projected onto the half-silvered combining glass, measured when the subject judges the sizes of the two images to be equal.

If the standard image is the horizon moon image, the ratio is given by the formula:

$$\frac{\text{comparison (variable) aperture diameter}}{\text{standard horizon aperture diameter}}$$

If the standard image is the zenith moon image, the ratio is given by:

$$\frac{\text{standard zenith aperture diameter}}{\text{comparison (variable) aperture diameter}}$$

Use of these formulaes insures that the dependent variable will reflect the apparent increase in size of the horizon moon over the zenith moon. If an illusion is present, the ratios will be greater than 1.0; the greater the illusion, the larger the number will be.

References

Boring, E. G. Sensation and Perception in the History of Experimental Psychology. New York: Appleton-Century, 1942. (See especially p. 292.)

Holway, A. H., & Boring, E. G. The moon illusion and the angle of regard. American Journal of Psychology, 1940 53, 109-116.

Kaufman, L., & Rock, I. The moon illusion, I. Science, 1962, 136, 953-961.

King, W. L., & Gruber, H. E. Moon illusion and emmert's law, Science, 1962, 135, 1125-1126.

Rock, I., & Kaufman, L. The moon illusion, II. Science, 1962, 136, 1023-1031.

Southall, J. P. C. (Ed.). Helmholtz's physiological optics. Optical Society of America, 1925, 3, pp. 290ff.

LABSIM / 2-FACTOR MIXED DESIGN

```
ENTER YOUR NAME.
GEORGE BERKELEY

ENTER YOUR LABSIM STUDENT NUMBER.
8

ENTER THE NUMBER OF A SIMULATION MODEL.
2

***** COMMUNICATION NETWORKS                                    *****

ENTER THE NUMBER OF INDEPENDENT VARIABLES.
2

ENTER THE NUMBER OF DEPENDENT VARIABLES.
2

ENTER THE NUMBER OF TREATMENT CONDITIONS IN YOUR EXPERIMENT.
6

ENTER THE NUMBER OF SUBJECTS OR GROUPS OF SUBJECTS ASSIGNED TO EACH CONDITION.
14

ENTER THE NUMBER OF EACH INDEPENDENT VARIABLE.
2 4

ENTER THE NUMBER OF LEVELS FOR EACH INDEPENDENT VARIABLE.
3 2

ENTER THE TYPE OF EACH INDEPENDENT VARIABLE.
3 1

ENTER THE NUMBER OF EACH DEPENDENT VARIABLE.
1 2

ENTER THE NUMERIC CODE FOR TYPE OF STATISTICAL TEST.
7

ENTER THE NUMERIC CODE FOR TYPE OF DATA TRANSFORMATION.
0

ENTER THE NUMBER OF REPLICATIONS DESIRED.
1

ENTER 1 LEVEL FOR COMPLEXITY
1

ENTER 3 LEVELS FOR STRUCTURE
1 2 3

ENTFR 1 LEVEL FOR SEX OF SUBJECT
0

ENTER 2 LEVELS FOR SUBMISSIVENESS
1 2
```

COMMUNICATION NETWORKS
LABORATORY SIMULATION

GEORGE BERKELEY STUDENT NUMBER 8

CHOICES FROM POTENTIAL VARIABLES

POTENTIAL VARIABLES	CONDITION 1	CONDITION 2	CONDITION 3	CONDITION 4	CONDITION 5	CONDITION 6
COMPLEXITY	*HIGH	*HIGH	*HIGH	*HIGH	*HIGH	*HIGH
STRUCTURE	*WHEEL	*CHAIN	*CIRCLE	*WHEEL	*CHAIN	*CIRCLE
SEX OF SUBJECT	*NO CONTROL	*NO CONTROL	*NO CONTROL	*NO CONTROL	*NO CONTROL	*NO CONTROL
SUBMISSIVENESS	*HIGH	*HIGH	*HIGH	*LOW	*LOW	*LOW

EXPERIMENTAL DESIGN TWO-FACTOR 3X2 (MIXED DESIGN)

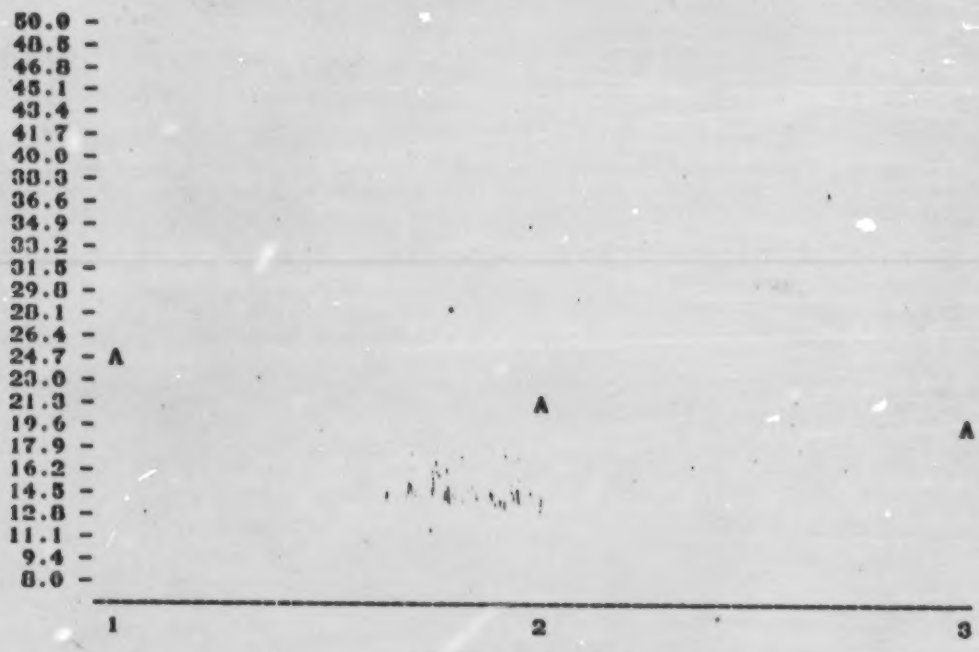
INDEPENDENT VARIABLE 1 STRUCTURE
INDEPENDENT VARIABLE 2 SUBMISSIVENESS

DEPENDENT VARIABLE MEAN NUMBER OF MESSAGES REQUIRED TO SOLVE FOUR PROBLEMS

RAW SCORES FOR REPLICATION 1

	CONDITION 1 GROUPS 1- 14	CONDITION 2 GROUPS 1- 14	CONDITION 3 GROUPS 1- 14	CONDITION 4 GROUPS 15- 28	CONDITION 5 GROUPS 15- 28	CONDITION 6 GROUPS 15- 28
	23.78	21.42	22.66	22.01	24.97	19.46
	26.92	22.82	19.45	28.60	20.84	20.03
	26.95	23.26	19.97	24.47	20.32	20.52
	22.98	20.06	20.05	24.39	21.56	21.11
	24.76	18.97	21.87	25.93	21.33	18.87
	26.96	18.98	22.51	23.61	21.19	18.13
	26.28	23.55	18.54	28.16	21.27	20.23
	24.59	23.39	17.18	27.04	21.52	19.78
	24.50	25.74	19.96	26.12	27.47	18.29
	24.42	17.79	16.29	25.98	19.81	19.44
	23.87	20.58	22.06	26.43	26.92	19.59
	24.89	22.84	16.76	21.33	23.52	15.58
	24.06	17.80	16.74	27.87	21.13	19.18
	25.35	26.06	16.63	21.10	21.44	18.21
SUM	350.31	303.21	270.67	353.04	313.29	268.42
SUMSQ	8787.15	6664.99	5304.55	8982.67	7086.12	5170.29
MEAN	25.02	21.66	19.33	25.22	22.38	19.17
STDV	1.29	2.72	2.35	2.48	2.41	1.36

PLOT OF TABLE A



A-MEANS

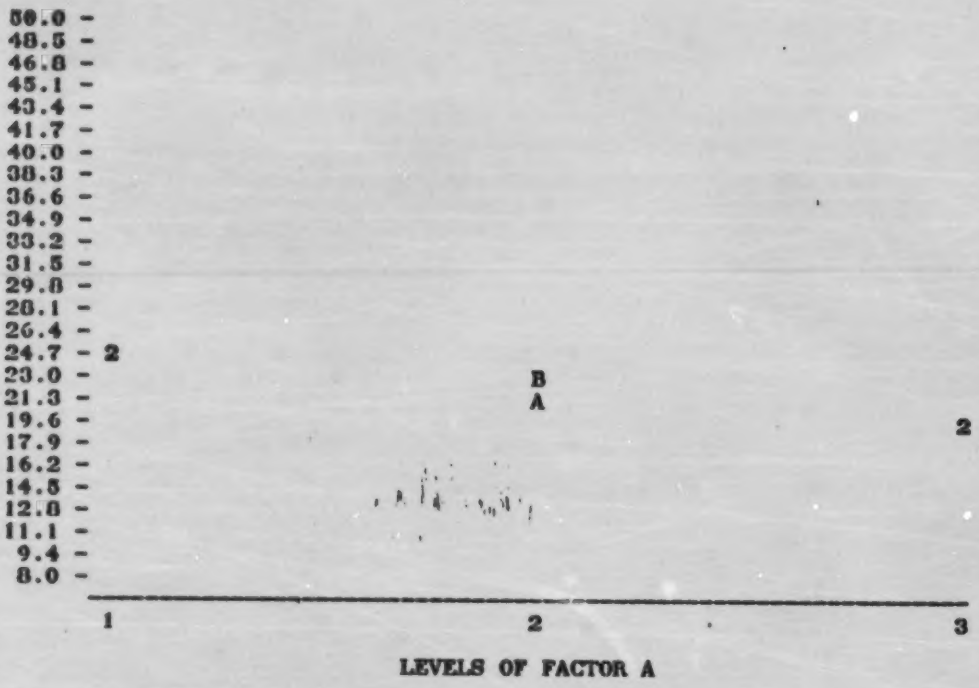
25.12	22.02	19.25

PLOT OF TABLE B

B-MEANS

22.01 22.26

PLOT OF TABLE AB



A-MEANS FOR SUCCESSIVE LEVELS OF ,B

25.02	21.66	19.33
25.22	22.38	19.17

ANALYSIS OF VARIANCE FOR COMMUNICATION NETWORKS
REPLICATION NUMBER 1

LABEL	FACTOR	NO. LEVELS
C	GROUPS	14
A	STRUCTURE	3
B	SUBMISSIVENESS	2

DEPENDENT VARIABLE = MEAN NUMBER OF MESSAGES REQUIRED TO SOLVE FOUR PROBLEMS

SOURCE OF VARIATION	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F STATISTIC	PROBABILITY VALUE
A	482.33	2	241.16	F(2,52) = 51.03,	P = 0.000 **
B	1.32	1	1.32	F(1,26) = 0.28,	P = 0.602
AB	2.72	2	1.36	F(2,52) = 0.29,	P = 0.751
ERR BETWEEN	122.66	26	4.72		
ERR A	245.74	52	4.73		
TOTAL	854.77	83			

* P < .05
** P < .01

GOOD EXPERIMENTAL DESIGN. $ 100.00 HAVE BEEN ADDED TO YOUR ACCOUNT.

EXPENDITURES

INITIAL BALANCE		$20000.00
SUBJECTS	$ 56.00	
CONTROL OF VARIABLES	$ 40.00	
COMPUTER TIME	$ 1.00	
TOTAL	-$ 97.00	
BONUS	$ 100.00	
FINAL BALANCE		$20003.00

LABSIM / 2-FACTOR MIXED DESIGN (CONT.)

EXPERIMENTAL DESIGN — TWO-FACTOR 3X2 (MIXED DESIGN)

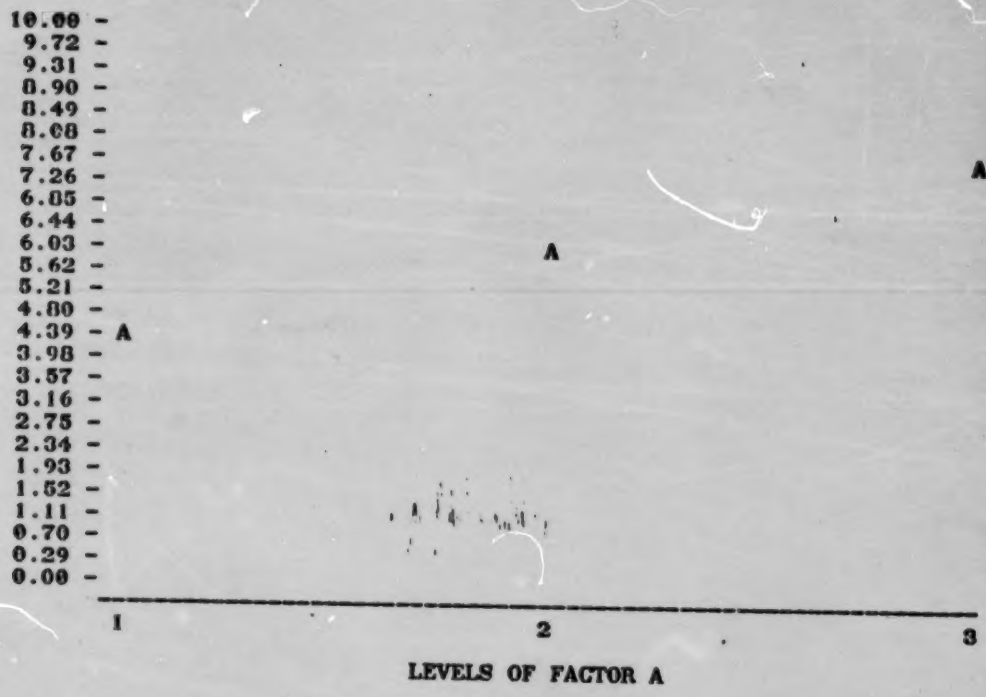
INDEPENDENT VARIABLE 1 — STRUCTURE
INDEPENDENT VARIABLE 2 — SUBMISSIVENESS

DEPENDENT VARIABLE — MEAN RATING OF JOB SATISFACTION ON A 10-POINT SCALE

RAW SCORES FOR REPLICATION 1

	CONDITION 1 GROUPS 1- 14	CONDITION 2 GROUPS 1- 14	CONDITION 3 GROUPS 1- 14	CONDITION 4 GROUPS 15- 28	CONDITION 5 GROUPS 15- 28	CONDITION 6 GROUPS 15- 28
	6.10	7.79	8.53	1.11	4.13	4.83
	6.09	7.76	8.35	2.94	4.07	6.92
	6.83	7.96	9.59	1.65	4.67	6.39
	7.56	7.81	9.48	1.61	4.18	6.32
	7.50	8.04	8.60	2.15	3.65	5.47
	7.12	7.57	9.88	2.19	4.33	5.52
	6.40	8.03	9.17	2.14	4.24	6.64
	6.26	7.92	8.94	2.60	3.40	6.49
	6.85	7.24	9.80	2.07	4.40	6.07
	7.69	8.74	9.12	1.96	4.30	5.90
	7.28	7.71	9.66	1.64	3.77	6.32
	6.11	8.29	9.59	2.02	3.51	6.19
	7.59	7.79	8.15	2.50	3.74	5.76
	7.28	8.10	9.37	2.40	4.03	5.80
SUM	96.66	110.75	128.31	28.98	56.42	84.62
SUMSQ	672.19	877.68	1180.20	62.86	229.12	515.32
MEAN	6.90	7.91	9.17	2.07	4.03	6.04
STDV	0.61	0.35	0.57	0.47	0.37	0.54

PLOT OF TABLE A



A-MEANS

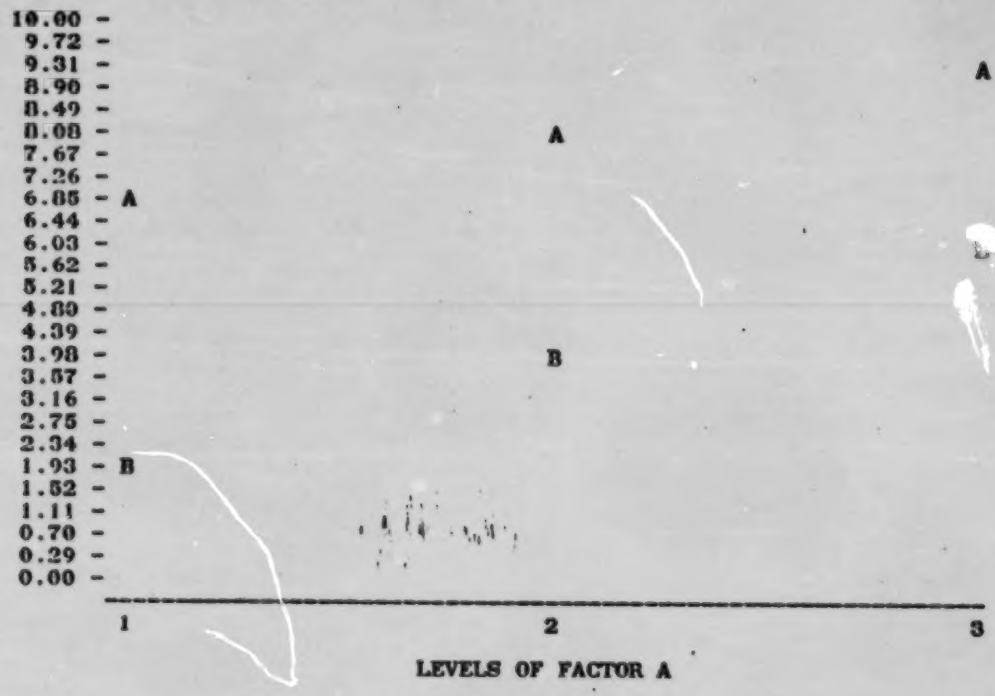
4.49	5.97	7.68

PLOT OF TABLE B

B-MEANS

7.99 4.05

PLOT OF TABLE AB



A-MEANS FOR SUCCESSIVE LEVELS OF ,B

6.90	7.91	9.17
2.07	4.03	6.04

ANALYSIS OF VARIANCE FOR COMMUNICATION NETWORKS
REPLICATION NUMBER 1

LABEL	FACTOR	NO. LEVELS
G	GROUPS	14
A	STRUCTURE	3
B	SUBMISSIVENESS	2

DEPENDENT VARIABLE = MEAN RATING OF JOB SATISFACTION ON A 10-POINT SCALE

SOURCE OF VARIATION	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F STATISTIC	PROBABILITY VALUE
A	136.17	2	68.08	F(2,52) = 296.65,	P = 0.000 **
B	326.86	1	326.86	F(1,26) = 1186.00,	P = 0.000 **
AB	10.32	2	5.16	F(2,52) = 22.48,	P = 0.000 **
ERR BETWEEN	7.17	26	0.28		
ERR A	11.93	52	0.23		
TOTAL	492.45	83			

* P < .05
** P < .01

GOOD EXPERIMENTAL DESIGN. $ 100.00 HAVE BEEN ADDED TO YOUR ACCOUNT.

EXPENDITURES

INITIAL BALANCE		$20003.00
SUBJECTS	$ 56.00	
CONTROL OF VARIABLES	$ 40.00	
COMPUTER TIME	$ 1.00	
TOTAL	-$ 97.00	
BONUS	$ 100.00	
FINAL BALANCE		$20006.00

EXPERIMENTAL DESIGN — TWO-FACTOR 2X2 (INDEPENDENT GROUPS)

INDEPENDENT VARIABLE 1 — QUESTION TYPE
INDEPENDENT VARIABLE 2 — QUESTION REFERENCE

DEPENDENT VARIABLE — SCORE ON 100-PT EXAMINATION

RAW SCORES FOR REPLICATION 2

CONDITION 1 SUBJECTS 1- 15	CONDITION 2 SUBJECTS 16- 30	CONDITION 3 SUBJECTS 31- 45	CONDITION 4 SUBJECTS 46- 60
51.	34.	54.	49.
58.	57.	57.	60.
38.	48.	54.	69.
51.	44.	47.	50.
58.	38.	46.	54.
51.	46.	43.	38.
58.	57.	44.	49.
72.	49.	32.	44.
46.	45.	39.	60.
61.	47.	28.	38.
48.	44.	27.	71.
77.	50.	31.	65.
53.	26.	35.	35.
66.	72.	61.	40.
24.	53.	45.	62.
SUM 812.00	710.00	643.00	784.00
SUMSQ 46334.00	35194.00	29181.00	42938.00
MEAN 54.13	47.33	42.87	52.27
STDV 13.03	10.65	10.75	11.83

(B) NUMBER OF SUBJECTS REJECTED FOR BEING OUTSIDE THE LIMITS OF A RANGE VARIABLE

RANGE VARIABLE	CONDITION 1	2	3	4
READING SCORE	0	0	1	0
IQ	0	0	0	0
TOTAL REJECTED	0	0	1	0

(C) DATA FOR REJECTED SUBJECTS

CONDITION 3
READING SCORE 109.

ENTER THE CODE FOR THE FILE TO BE ACCESSED.
2

ENTER THE CODE FOR THE TYPE OF UPDATE DESIRED:
7

STUDENT NUMBER 1

SUMMARY STATISTICS

TOTAL SUBMITTED	TOTAL EXECUTED	PERCENT EXECUTED	TOTAL 2-GROUP	TOTAL PARAMETRIC	TOTAL 2-FACTOR	TOTAL 3-FACTOR	TOTAL ERRORS
1	1	100.00	0	0	0	1	0

SIMULATION MODEL NUMBER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
BALANCE	$14909.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.
TOTAL SUBMITTED	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL EXECUTED	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TWO-GROUP DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARAMETRIC DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TWO-FACTOR DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MIXED	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THREE-FACTOR DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MIXED	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ERROR ANALYSIS														
OVERDRAWN ACCOUNT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DATA INPUT ERRORS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBJECT VARIABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPERIMENTAL VAR.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RANGE VARIABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DUMMY VARIABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANALYSIS PROCEDURE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IMPROPER CONTROLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0

STUDENT NUMBER 2

SUMMARY STATISTICS

TOTAL SUBMITTED	TOTAL EXECUTED	PERCENT EXECUTED	TOTAL 2-GROUP	TOTAL PARAMETRIC	TOTAL 2-FACTOR	TOTAL 3-FACTOR	TOTAL ERRORS
12	11	91.67	5	4	1	1	1

SIMULATION MODEL NUMBER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
BALANCE	$14460.	$15083.	$14883.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$14825.	$14869.	$15000.	
TOTAL SUBMITTED	5	2	2	0	0	0	0	0	0	0	0	1	1	1
TOTAL EXECUTED	4	2	2	0	0	0	0	0	0	0	0	1	1	1
TWO-GROUP DESIGNS														
INDEPENDENT GROUPS	0	2	0	0	0	0	0	0	0	0	0	0	1	1
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	1	0	0
PARAMETRIC DESIGNS														
INDEPENDENT GROUPS	0	0	1	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	3	0	0	0	0	0	0	0	0	0	0	0	0	0
TWO-FACTOR DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MIXED	0	0	1	0	0	0	0	0	0	0	0	0	0	0
THREE-FACTOR DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MIXED	1	0	0	0	0	0	0	0	0	0	0	0	0	0
ERROR ANALYSIS														
OVERDRAWN ACCOUNT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DATA INPUT ERRORS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBJECT VARIABLE	1	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPERIMENTAL VAR.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RANGE VARIABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DUMMY VARIABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANALYSIS PROCEDURE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IMPROPER CONTROLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0

STUDENT NUMBER 10

SUMMARY STATISTICS

TOTAL SUBMITTED	TOTAL EXECUTED	PERCENT EXECUTED	TOTAL 2-GROUP	TOTAL PARAMETRIC	TOTAL 2-FACTOR	TOTAL 3-FACTOR	TOTAL ERRORS
4	4	100.00	0	3	0	1	1

SIMULATION MODEL NUMBER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
BALANCE	$14954.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.	$15000.
TOTAL SUBMITTED	3	0	0	0	0	1	0	0	0	0	0	0	0	0
TOTAL EXECUTED	3	0	0	0	0	1	0	0	0	0	0	0	0	0
TWO-GROUP DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARAMETRIC DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	3	0	0	0	0	0	0	0	0	0	0	0	0	0
TWO-FACTOR DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MIXED	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THREE-FACTOR DESIGNS														
INDEPENDENT GROUPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPEATED MEASURES	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MIXED	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ERROR ANALYSIS														
OVERDRAWN ACCOUNT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DATA INPUT ERRORS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBJECT VARIABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPERIMENTAL VAR.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RANGE VARIABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DUMMY VARIABLE	0	0	0	0	0	1	0	0	0	0	0	0	0	0
ANALYSIS PROCEDURE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IMPROPER CONTROLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0

THE FOLLOWING STUDENTS DID NOT SUBMIT AN EXPERIMENT:

STUDENT IDENTIFICATION NUMBER

3
6
9
15
18
21
22
23

```
ENTER THE CODE FOR THE FILE TO BE ACCESSED.
2

ENTER THE CODE FOR THE TYPE OF UPDATE DESIRED.
8

ENTER THE NUMBER OF A SIMULATION MODEL.
1

ENTER ONE (1) TO PRINT EMPTY STUDENT RECORDS.  OTHERWISE ENTER ZERO (0).
0
```

DEFINITION OF COLUMN HEADINGS

1 = BALANCE IN ACCOUNT
2 = TOTAL EXPERIMENTS SUBMITTED
3 = TOTAL EXPERIMENTS EXECUTED

TYPE OF EXPERIMENT
4 = TWO-GROUP DESIGN (INDEPENDENT GROUPS)
5 = TWO-GROUP DESIGN (REPEATED MEASURES)
6 = PARAMETRIC DESIGN (INDEPENDENT GROUPS)
7 = PARAMETRIC DESIGN (REPEATED MEASURES)
8 = TWO-FACTOR DESIGN (INDEPENDENT GROUPS)
9 = TWO-FACTOR DESIGN (REPEATED MEASURES)
10 = TWO-FACTOR DESIGN (MIXED)
11 = THREE-FACTOR DESIGN (INDEPENDENT GROUPS)
12 = THREE-FACTOR DESIGN (REPEATED MEASURES)
13 = THREE-FACTOR DESIGN (MIXED)

TYPE OF ERROR
14 = OVERDRAWN ACCOUNT
15 = DATA INPUT ERRORS
16 = IMPROPER USE OF SUBJECT VARIABLE
17 = IMPROPER USE OF EXPERIMENTAL VARIABLE
18 = IMPROPER SELECTION OF RANGE VARIABLE VALUES
19 = DUMMY VARIABLE USED AS INDEPENDENT VARIABLE
20 = IMPROPER ANALYSIS PROCEDURE
21 = IMPROPER CONTROL OF VARIABLES

SIMULATION MODEL NUMBER 1

STUDENT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	$14909.	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2	$14460.	5	4	0	0	0	3	0	0	0	0	0	1	0	0	1	0	0	0	0	0
4	$14974.	4	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	$15000.	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
7	$14922.	2	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
8	$14869.	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
10	$14954.	3	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	$14738.	8	8	1	0	3	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
14	$14876.	7	6	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17	$14907.	2	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0
19	$14503.	8	7	0	0	2	0	3	0	0	0	0	2	0	1	0	0	0	0	0	0
27	$14940.	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	$14876.	2	2	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
31	$13549.	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

SUMMARY STATISTICS

TOTAL SUBMITTED	TOTAL EXECUTED	PERCENT EXECUTED	TOTAL 2-GROUP	TOTAL PARAMETRIC	TOTAL 2-FACTOR	TOTAL 3-FACTOR	TOTAL ERRORS
47	42	89.36	13	13	9	7	8

```
ENTER THE CODE FOR THE FILE TO BE ACCESSED.
2

ENTER THE CODE FOR THE TYPE OF UPDATE DESIRED.
10


ENTER THE NUMBER OF STUDENT RECORDS TO BE PRINTED.
7

ENTER 7 STUDENT NUMBER/MODEL NUMBER PAIRS.
13 1 18 3 24 5 19 1 2 14 8 3 26 11
```

DEFINITION OF COLUMN HEADINGS

1 = BALANCE IN ACCOUNT
2 = TOTAL EXPERIMENTS SUBMITTED
3 = TOTAL EXPERIMENTS EXECUTED

TYPE OF EXPERIMENT
4 = TWO-GROUP DESIGN (INDEPENDENT GROUPS)
5 = TWO-GROUP DESIGN (REPEATED MEASURES)
6 = PARAMETRIC DESIGN (INDEPENDENT GROUPS)
7 = PARAMETRIC DESIGN (REPEATED MEASURES)
8 = TWO-FACTOR DESIGN (INDEPENDENT GROUPS)
9 = TWO-FACTOR DESIGN (REPEATED MEASURES)
10 = TWO-FACTOR DESIGN (MIXED)
11 = THREE-FACTOR DESIGN (INDEPENDENT GROUPS)
12 = THREE-FACTOR DESIGN (REPEATED MEASURES)
13 = THREE-FACTOR DESIGN (MIXED)

TYPE OF ERROR
14 = OVERDRAWN ACCOUNT
15 = DATA INPUT ERRORS
16 = IMPROPER USE OF SUBJECT VARIABLE
17 = IMPROPER USE OF EXPERIMENTAL VARIABLE
18 = IMPROPER SELECTION OF RANGE VARIABLE VALUES
19 = DUMMY VARIABLE USED AS INDEPENDENT VARIABLE
20 = IMPROPER ANALYSIS PROCEDURE
21 = IMPROPER CONTROL OF VARIABLES

STUDENT NUMBER	MODEL NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
13	1	$14738.	8	8	1	8	3	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
18	3	$15000.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	5	$14845.	3	1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
19	1	$14503.	8	7	0	0	2	0	3	0	0	0	0	2	0	1	0	0	0	0	0	0
2	14	$15000.	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	3	$15000.	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
26	11	$15000.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABSIM / AVAILABLE MODELS

1. ADAPTATION LEVEL AND JUDGMENT OF LINE LENGTH
2. COMMUNICATION NETWORKS
3. CONCEPT LEARNING AND CONCEPT SHIFTS
4. SPACING OF PRACTICE IN THE ACQUISITION OF SKILLS
5. SYSTEMATIC DESENSITIZATION
6. KNOWLEDGE OF CORRECT RESPONSE IN PROGRAMMED INSTRUCTION
7. SERIAL POSITION EFFECTS IN FREE RECALL
8. DECISION TIMES FOR ALPHABETIC ORDER
9. EFFECTIVENESS OF STUDY ACTIVITIES ON RETENTION
10. READING AND COMPREHENSION OF TEXT MATERIALS
11. EFFECT OF ADJUNCT QUESTIONS ON RETENTION OF PROSE
12. THE MOON ILLUSION
13. THE STROOP TEST
14. THE LOST LETTER
15. THE AUTOKINETIC ILLUSION

LABSIM / ADVANTAGES OF SIMULATION

1. Research problems may be tailored to the individual interests of the students.
2. The student's attention is focused on the decision-making processes involved in designing programs of research.
3. Eliminates the time consuming data collection task.
4. Provides for a greater degree of control over the results of experiments.
5. Large numbers of experiments can be conducted in a relatively short period of time.
6. Experiments can be repeated easily.
7. Experiments having moderate to high levels of complexity may be performed.
8. Rapid feedback may be provided for errors in experimental designs and for experimental results.
9. More instructional time is available since simulations are performed outside of the class.
10. Experiments can be simulated that are impractical or impossible to conduct in the real laboratory.
11. Gaming strategies may be used to increase the student's motivational level, focus attention on the economic constraints of research decisions and facilitate communication between students.
12. Automatic monitoring systems enable early identification of student problems.
13. More cost effective than real laboratory exercises.

LABSIM / DOCUMENTATION

- INSTRUCTOR MANUAL
- STUDENT MANUAL
- MODEL MANUAL

LABSIM / SPECIAL FEATURES

COMPUTER EXPERTISE NOT REQUIRED

FLEXIBILITY

- DEVELOPMENT OF NEW MODELS
- MODIFICATION OF EXISTING MODELS

TRANSPORTABILITY

Computer Simulations to Demonstrate Statistical Principles

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The purpose of this paper is to present general methods and specific examples of how to produce computer simulations of empirical events that demonstrate principles covered in introductory statistics courses. Classroom demonstrations of coin flipping and random sampling are sometimes included in statistics courses but are sometimes more time-consuming than one would like and are limited if one needs a very large number of events to make a point with the demonstration. Other demonstrations, for example, producing a few hundred random correlations to show how they are normally distributed, are just out of the question without the computer. This paper will show how to produce demonstrations with MINITAB, a general purpose statistical program found on many university systems.

MINITAB is a FORTRAN program written by Ryan, Joiner, and Ryan at Pennsylvania State University. It is usually used to analyze and store data from experiments but it has capabilities that make it a high-level programming language well suited to producing simulations and demonstrations. One feature is its ability to produce random data columns or columns of random samples from populations with specified characteristics. Another feature is MINITAB's ability to store a sequence of commands, to retrieve the command sequence and execute it a repeated number of times. Finally, MINITAB can retrieve a stored set of data, called a "worksheet," manipulate the data and possibly create new data in the process, and store the new worksheet for retrieval and further modification later. The Version 80.1 revision of MINITAB is used in the examples that accompany this presentation. To create these examples, MINITAB was run interactively on a DEC-10 computer at the Locke Computer Center at the University of Washington.

When these demonstrations are produced for the classroom it is best to show them to students in real time on equipment that allows the students to watch the computer's output as it appears. I do this using an ACT-IA terminal which outputs directly to a small TV monitor I can see and a large TV screen that the students can watch. This arrangement has been fairly inexpensive and seems to yield satisfactory results.

The general procedure for producing a simulation follows:

GENERAL PROCEDURE

I. Advance Preparation

A. In MINITAB, create a worksheet with required columns of input data. Save this worksheet with SAVE command.

B. Create the stored sequence of commands. This is done by giving the STORE command to MINITAB, then entering the commands one per line, then giving the END command to MINITAB.

1. MINITAB will store the command sequence with a file name of FOR60.DAT or a similar default filename. If a file named FOR60.DAT already exists, MINITAB will delete it and replace it with the new file. See IC, below.
2. The stored command sequence can also be written using a file writer/editor outside of MINITAB. This makes writing and editing easier, but does not check for errors. MINITAB doesn't do much error checking before execution, either, though.

C. Leave MINITAB, return to the Monitor or Command level and rename file FOR60.DAT so that it has some other name. This way you won't accidentally write over it when you create another stored command sequence. See IB1, above.

II. To Execute the Demonstration

A. Enter MINITAB and give the RETRieve command. When MINITAB asks for a filename, give the worksheet filename assigned in step IA, above.

B. Give the EXECUTE command, followed by the number of times you wish the command sequence to be execute . Some simulations require repeated passes before the point of the simulation becomes obvious. When MINITAB asks for the file name of the stored commands, respond with the name assigned in step IC, above.

C. Let the executed sequence proceed. On some systems,aa control character will suppress unwanted output if you do not want to display the repetitious output of the stored commands (e. g. Control-O).

D. Some of the demonstrations show their results during execution, others complete execution without showing results. Their results are stored in a worksheet column. When this is the case, give the HISTOGRAM command to get a bar chart of the data in that column or the DESCRIBE command if you want to show students the mean and standard deviation of the column.

III. After the Demonstration

A. If the demonstration has created data on the worksheet, you may wish to save the worksheet in its new form so that the next demonstration will begin with these data already in it. For example, the worksheet may have a column with 50 sample means in C4 as a result of your

first demonstration. By saving this worksheet you can begin the next demonstration at that point and add on another 50 means. To save the worksheet in its altered form, give the SAVE command to MINITAB. When it asks for a file name for saving, giving its old file name will replace the original worksheet; giving a new file name will create a new worksheet in addition to your original one.

```
MINITAB RELEASE 80.1 *** COPYRIGHT - PENN STATE UNIV. 1980
APRIL  2, 1981 *** Locke Computer Center -- Version 1.0
STORAGE AVAILABLE   5000

-- RETRIEVE

FILE NAME FOR RETRIEVAL ? :WORK3.SIM

-- EXECUTE 30

FILE NAME OF STORED COMMNDS?  STAT3.SIM

-- NOPRINT

-- SAMPLE 30 FROM C1 PUT IN C2

-- AVERAGE OF C2 INTO C3
   AVERAGE =       49.240

-- PICK ROWS 1 TO 1 FROM C3 PUT INTO C3

-- JOIN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS

**** INFORMATIVE DIAGNOSTIC
**** COMMAND EXECUTED AND COMPUTATION CONTINUES
*
* NO DATA IN COLUMN                                          ...N OF SAMPLE MEANS
*
**** MESSAGE REFERS TO COMMAND ABOVE


-- NOPRINT

-- SAMPLE 30 FROM C1 P...                    30 REPETITIONS

-- AVERAGE OF
   AVERA...  ... TO 1 FROM C3 PUT INTO C3

   ...IN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS

   END OF EXECUTION OF STORED INSTRUCTIONS
--

-- HIST C4

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
       44.          1     *
       46.          3     ***
       48.          7     *******
       50.          8     ********
       52.          5     *****
       54.          3     ***
       56.          0
       58.          3     ***
```

MINITAB COMMANDS FOR SIMULATIONS

Constructing a distribution of means of samples randomly drawn from a normally distributed population. Demonstrates central limits theorum, standard error of mean.

To create the worksheet:
NRANDOM 1000 1 100 C1

Stored command sequence:

```
NOPRINT
SAMPLE 30 FROM C1 PUT IN C2
AVERAGE OF C2 INTO C3
PICK ROWS 1 TO 1 FROM C3 PUT INTO C3
JOIN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS
```

Each execution stores an additional sample mean in C4.

HIST C4 will display distribution of sample means.

SAVE will save worksheet with column of means intact. RETRIEVE will allow additional executions and added sample means.

Distribution will approach normal distribution as number of executions increases. Mean of C4 may be obtained by command DESC C4. Mean of samples will approach population mean (obtained by command AVERAGE C1) and standard deviation of C4 will approach standard error of mean.

```
MINITAB RELEASE 80.1 *** COPYRIGHT - PENN STATE UNIV. 1980
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STORAGE AVAILABLE   5000

-- RETRIEVE

FILE NAME FOR RETRIEVAL ? :WORK1.SIM

-- EXECUTE 30

FILE NAME OF STORED COMMNDS?  STAT1.SIM

-- NOPRINT

-- SAMPLE 30 FROM C1 PUT IN C2

-- AVERAGE OF C2 INTO C3
   AVERAGE =       48.724

-- PICK ROWS 1 TO 1 FROM C3 PUT INTO C3

-- JOIN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS

**** INFORMATIVE DIAGNOSTIC
**** COMMAND EXECUTED AND COMPUTATION CONTINUES
*
* NO DATA IN COLUMN
*
**** MESSAGE REFERS TO COMMAND ABOVE


-- NOPRINT

-- SAMPLE 30 FROM C1 [illegible]

-- AVERA[illegible]
      30 REPETITIONS
      [illegible] 1 FROM C3 PUT INTO C3

   JOIN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS

   END OF EXECUTION OF STORED INSTRUCTIONS

-- HIST C4

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
       47.          1     *
       48.          2     **
       49.          6     ******
       50.          7     *******
       51.          7     *******
       52.          4     ****
       53.          3     ***
```

MINITAB COMMANDS FOR SIMULATIONS

Constructing a distribution of means of samples randomly drawn from a randomly distributed population. Demonstrates central limits theorum, standard error of mean.

To create the worksheet:
IRANDOM 1000 1 100 C1

Stored command sequence:

```
NOPRINT
SAMPLE 30 FROM C1 PUT IN C2
AVERAGE OF C2 INTO C3
PICK ROWS 1 TO 1 FROM C3 PUT INTO C3
JOIN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS
```

Each execution stores an additional sample mean in C4.

HIST C4 will display distribution of sample means.

SAVE will save worksheet with column of means intact. RETRIEVE will allow additional executions and added sample means.

Distribution will approach normal distribution as number of executions increases. Mean of C4 may be obtained by command DESC C4. Mean of samples will approach population mean (obtained by command AVERAGE C1) and standard deviation of C4 will approach standard error of mean.

```
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STORAGE AVAILABLE   5000

-- RETRIEVE

FILE NAME FOR RETRIEVAL ? :WORK2.SIM

-- EXECUTE 30

FILE NAME OF STORED COMMNDS?  STAT2.SIM

-- NOPRINT

-- SAMPLE 30 FROM C1 PUT IN C2

-- AVERAGE OF C2 INTO C3
   AVERAGE =       48.833

-- PICK ROWS 1 TO 1 FROM C3 PUT INTO C3

-- JOIN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS

**** INFORMATIVE DIAGNOSTIC
**** COMMAND EXECUTED AND COMPUTATION CONTINUES
*
* NO DATA IN COLUMN
*
**** MESSAGE REFERS TO COMMAND ABOVE

-- NOPRINT

-- EXECUTE 30

FILE NAME OF STORED COMMNDS?  STAT2.SIM

-- NOPRINT

-- SAMPLE 30 FROM C1 PUT IN C2

-- AVERAGE OF C2 INTO C3
   AVERAGE =       48.833

-- PICK ROWS 1 TO 1 FROM C3 PUT INTO C3

-- JOIN C3 TO BOTTOM OF C4 PUT INTO C4 WHICH WILL BE COLUMN OF SAMPLE MEANS

**** INFORMATIVE DIAGNOSTIC
**** COMMAND EXECUTED AND COMPUTATION CONTINUES
*
* NO DATA IN COLUMN
*
**** MESSAGE REFERS TO COMMAND ABOVE

-- NOPRINT

-- EXECUTION OF STORED INSTRUCTIONS

-- HIST C4

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
       45.          1     *
       46.          0
       47.          1     *
       48.          2     **
       49.          5     *****
       50.          5     *****
       51.          7     *******
       52.          5     *****
       53.          0
       54.          3     ***
       55.          0
       56.          1     *

-- REST
```

30 REPETITIONS

MINITAB COMMANDS FOR SIMULATIONS

Constructs a distribution of differences between means of randomly drawn pairs of samples. Demonstrates normal distribution of distribution of differences. Shows mean of such a distribution approaches 0.

To create the worksheet:

IRAN 1000 1 100 C1

Stored command sequence:

```
NOPRINT
SAMPLE 30 C1 C2
SAMPLE 30 C1 C3
AVERAGE C2 C4
AVERAGE C3 C5
PICK 1 1 C4 C4
PICK 1 1 C5 C5
SUBTRACT C4 C5 C5
JOIN C5 C6 C6
```

HIST C6 will show distribution of differences between means.

SAVE will save worksheet with column of mean differences intact. RETRIEVE and additional executions will add to this column.

Increased executions will increase normalcy of distribution and will move mean of mean differences closer to 0. Display mean of mean differences with command AVER C6. DESC C6 will show mean and standard deviation of differences between means.

```
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APRIL  2, 1981 *** Locke Computer Center -- Version 1.0
STORAGE AVAILABLE    5000

-- RETRIEVE

FILE NAME FOR RETRIEVAL ? :WORK4.SIM

-- EXECUTE 30

FILE NAME OF STORED COMMNDS?  STAT4.SIM

-- NOPRINT

-- SAMPLE 30 C1 C2

-- SAMPLE 30 C1 C3

-- AVERAGE C2 C4
   AVERAGE =       99.633

-- AVERAGE C3 C5
   AVERAGE =       44.633

-- PICK 1 1 C4 C4

-- PICK 1 1 C5 C5

-- SUBTRACT C4 C5 C5
   ANSWER =        --

-- JOIN C5 -

--

        - 1 C5 C5

  - SUBTRACT C4 C5 C5
   ANSWER =         17.2333

-- JOIN C5 C6 C6

   END OF EXECUTION OF STORED INSTRUCTIONS
--

-- HISTOGRAM C6

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
      -60.        0
      -50.        1     *
      -40.        0
      -30.        0
      -20.        2     **
      -10.       16     ****************
        0.       31     *******************************
       10.       19     *******************
       20.        1     *
```

30 REPETITIONS

MINITAB COMMANDS FOR SIMULATIONS

Runs repeated independent-groups t tests on random samples of 30 scores drawn from the same population of 1000 scores. Occasional runs will produce sample means different enough to justify rejection of the null hypothesis at the .05 level. This demonstrates Type I error. One can also discuss the subjectivity of a choice of alpha level.

To create the worksheet:

```
NRAN 1000 50 10 C1
```

Stored command sequence:

```
NOPRINT
SAMPLE 30 FROM C1, PUT IN C2
SAMPLE 30 FROM C1, PUT IN C3
BRIEF 1 REPORT OF T-TEST
POOLED VARIANCE T-TEST OF C2 VS C3, DRAWN FROM SAME POPULATION
```

Each execution produces a t test on a new pair of samples.

```
MINITAB RELEASE 80.1 *** COPYRIGHT - PENN STATE UNIV. 1980
APRIL  2, 1981 *** Locke Computer Center -- Version 1.0
STORAGE AVAILABLE   5000

-- RETRIEVE

FILE NAME FOR RETRIEVAL ? :WORK5.SIM

-- EXEC 4

FILE NAME OF STORED COMMNDS?  STAT5.SIM

-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C2

-- SAMPLE 30 FROM C1, PUT IN C3

-- BRIEF 1 REPORT OF T-TEST

-- POOLED VARIANCE T-TEST OF C2 VS C3, DRAWN FROM SAME POPULATION
   C2          N =  30     MEAN =      48.724     ST. DEV. =       8.84
   C3          N =  30     MEAN =      52.066     ST. DEV. =       10.9

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (     -8.4653,      1.7825)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T = -1.306
   THE TEST IS SIGNIFICANT AT  0.1968
   CANNOT REJECT AT ALPHA = 0.05


-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C2

-- SAMPLE 30 FROM C1, PUT IN C3

-- BRIEF 1 REPORT OF T-TEST

-- POOLED VARIANCE T-TEST OF C2 VS C3, DRAWN FROM SAME POPULATION
   C2          N =  30     MEAN =      53.438     ST. DEV. =       10.3
   C3          N =  30     MEAN =      51.445     ST. DEV. =       11.0

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (     -3.5163,      7.5023)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T =  0.724
   THE TEST IS SIGNIFICANT AT  0.4718
   CANNOT REJECT AT ALPHA = 0.05


-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C2
```

```
-- SAMPLE 30 FROM C1, PUT IN C3

-- BRIEF 1 REPORT OF T-TEST

-- POOLED VARIANCE T-TEST OF C2 VS C3, DRAWN FROM SAME POPULATION
   C2          N =  30     MEAN =      50.510     ST. DEV. =      10.8
   C3          N =  30     MEAN =      52.945     ST. DEV. =      9.97

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (     -7.8141,      2.9455)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T = -0.906
   THE TEST IS SIGNIFICANT AT  0.3687
   CANNOT REJECT AT ALPHA = 0.05


-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C2

-- SAMPLE 30 FROM C1, PUT IN C3

-- BRIEF 1 REPORT OF T-TEST

-- POOLED VARIANCE T-TEST OF C2 VS C3, DRAWN FROM SAME POPULATION
   C2          N =  30     MEAN =      50.476     ST. DEV. =      7.75
   C3          N =  30     MEAN =      49.938     ST. DEV. =      8.82

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (     -3.7551,      4.8322)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T =  0.251
   THE TEST IS SIGNIFICANT AT  0.8026
   CANNOT REJECT AT ALPHA = 0.05


   END OF EXECUTION OF STORED INSTRUCTIONS
-- NOTE REPEATED EXECUTIONS WILL PRODUCE SOME TYPE I             ERRORS

--
```

MINITAB COMMANDS FOR SIMULATIONS

Runs repeated independent-groups t tests on random samples of 30 scores drawn from two populations of 1000. The mean of one population is 53.5. The mean of the other is 50. Occasionally the differences between the sample means will not be large enough to justify rejection of the null hypothesis at the .05 level, thus creating a Type II error.

To create the worksheet:

```
NRAN 1000 53.5 5 C1
NRAN 1000 50 5 C2
```

Stored command sequence:

```
NOPRINT
SAMPLE 30 FROM C1, PUT IN C3
SAMPLE 30 FROM C2, PUT IN C4
POOLED VARIANCE T-TEST OF C3 VS C4, DRAWN FROM DIFFERENT POPULATIONS
```

Each execution produces a t test on a new pair of samples.

```
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APRIL  2, 1981 *** Locke Computer Center -- Version 1.0
STORAGE AVAILABLE   5000

-- RETR

FILE NAME FOR RETRIEVAL ? :WORK6.SIM

-- EXECUTE 5

FILE NAME OF STORED COMMNDS?  W/W/STAT6.SIM

-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C3

-- SAMPLE 30 FROM C2, PUT IN C4

-- POOLED VARIANCE T-TEST OF C3 VS C4, DRAWN FROM DIFFERENT POPULATIONS
   C3          N =  30      MEAN =       54.397      ST.DEV. =       5.48
   C4          N =  30      MEAN =       50.179      ST.DEV. =       4.64

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (      1.5907,      6.8441)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T =  3.215
   THE TEST IS SIGNIFICANT AT  0.0021


-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C3

-- SAMPLE 30 FROM C2, PUT IN C4

-- POOLED VARIANCE T-TEST OF C3 VS C4, DRAWN FROM DIFFERENT POPULATIONS
   C3          N =  30      MEAN =       55.656      ST.DEV. =       5.50
   C4          N =  30      MEAN =       47.624      ST.DEV. =       5.12

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (      5.2861,     10.7787)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T =  5.856
   THE TEST IS SIGNIFICANT AT  0.0000


-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C3

-- SAMPLE 30 FROM C2, PUT IN C4

-- POOLED VARIANCE T-TEST OF C3 VS C4, DRAWN FROM DIFFERENT POPULATIONS
   C3          N =  30      MEAN =       52.634      ST.DEV. =       4.86
   C4          N =  30      MEAN =       51.988      ST.DEV. =       5.69
```

```
   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (    -2.0879,      3.3802)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T =  0.473
   THE TEST IS SIGNIFICANT AT  0.6379
   CANNOT REJECT AT ALPHA = 0.05


-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C3

-- SAMPLE 30 FROM C2, PUT IN C4

-- POOLED VARIANCE T-TEST OF C3 VS C4, DRAWN FROM DIFFERENT POPULATIONS
   C3         N =  30     MEAN =      53.744     ST.DEV. =      4.41
   C4         N =  30     MEAN =      48.155     ST.DEV. =      4.09

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (     3.3908,      7.7874)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T =  5.090
   THE TEST IS SIGNIFICANT AT  0.0000


-- NOPRINT

-- SAMPLE 30 FROM C1, PUT IN C3

-- SAMPLE 30 FROM C2, PUT IN C4

-- POOLED VARIANCE T-TEST OF C3 VS C4, DRAWN FROM DIFFERENT POPULATIONS
   C3         N =  30     MEAN =      52.780     ST.DEV. =      5.54
   C4         N =  30     MEAN =      49.631     ST.DEV. =      4.70

   DEGREES OF FREEDOM =  58

   A 95.00  PERCENT C.I.  FOR MU1-MU2 IS (     0.4921,      5.8054)

   TEST OF MU1 = MU2 VS.  MU1 N.E.  MU2
   T =  2.373
   THE TEST IS SIGNIFICANT AT  0.0210


   END OF EXECUTION OF STORED INSTRUCTIONS
-- NOTE ONE TYPE II ERROR ABOVE

-- STOP

*** MINITAB *** STATISTICS DEPT * PENN STATE UNIV.  * RELEASE 80.1 *
STORAGE AVAILABLE     5000

STOP

END OF EXECUTION
CPU TIME:  51.49 ELAPSED TIME:  19:2.70
```

MINITAB COMMANDS FOR SIMULATIONS

Produces a frequency distribution of correlation coefficients from all combinations of 16 groups of 25 scores randomly drawn from the same population. Demonstrates that the mean of random correlations approaches 0 and that occasional correlations are large enough to appear significant even though no true correlation exists. For df = 24, an r of .39 is significant at the .05 level and an r of .50 is significant at the .01 level.

To create the worksheet:
No worksheet is required for this demonstration.

Stored command sequence:

```
NOPRINT
IRAN 25 20 60 C1
IRAN 25 20 60 C2
IRAN 25 20 60 C3
IRAN 25 20 60 C4
IRAN 25 20 60 C5
IRAN 25 20 60 C6
IRAN 25 20 60 C7
IRAN 25 20 60 C8
IRAN 25 20 60 C9
IRAN 25 20 60 C10
IRAN 25 20 60 C11
IRAN 25 20 60 C12
IRAN 25 20 60 C13
IRAN 25 20 60 C14
IRAN 25 20 60 C15
IRAN 25 20 60 C16
CORR C1-C16 M1
COPY M1 C20-C35
JOIN C35 C34 C33 C32 C31 C30 C29 C28 C27 C26 C25 C24 C23 C22 C21 C20 C20
OMIT ROWS WITH 1.00 IN C20 PUT BACK IN C20
HIST C20 -.95 .05
AVERAGE C20
```

A single execution will produce a histogram and an average r for 250 pairs of samples. The program deletes autocorrelations (digonals, communalities) where r = 1.00, but it does not delete half the correlations that should not be counted because $r_{xy} = r_{yx}$. This does not affect the mean but it does double the frequencies shown in the histogram.

```
-- EXECUTE
-- NOPRINT
-- IRAN 25 20 60 C1
-- IRAN 25 20 60 C2
-- IRAN 25 20 60 C3
-- IRAN 25 20 60 C4
-- IRAN 25 20 60 C5
-- IRAN 25 20 60 C6
-- IRAN 25 20 60 C7
-- IRAN 25 20 60 C8
-- IRAN 25 20 60 C9
-- IRAN 25 20 60 C10
-- IRAN 25 20 60 C11
-- IRAN 25 20 60 C12
-- IRAN 25 20 60 C13
-- IRAN 25 20 60 C14
-- IRAN 25 20 60 C15
-- IRAN 25 20 60 C16
-- CORR C1-C16 M1
```

	C1	C2	C3	C4	C5	C6	C7	C8	
C2	-0.053								
C3	-0.051	0.066							
C4	0.010	-0.010	0.109						
C5	0.052	-0.063	-0.061	-0.175					
C6	-0.047	-0.093	0.055	0.254	0.051				
C7	0.373	-0.145	-0.230	-0.117	-0.017	-0.056			
C8	0.349	0.026	0.211	0.055	-0.028	-0.193	-0.067		
C9	-0.062	0.147	0.132	0.032	0.051	-0.507	-0.160	-0.153	
C10	-0.151	0.255	0.068	0.315	-0.042	0.002	-0.166	-0.190	0.
C11	0.068	0.245	0.291	0.155	-0.099	0.372	-0.202	0.016	-0.
C12	-0.029	-0.227	0.036	-0.055	-0.360	0.113	0.053	-0.104	-0.
C13	-0.059	0.064	-0.105	0.276	0.210	0.171	0.053	-0.231	-0.
C14	0.149	-0.204	0.207	0.189	0.211	-0.080	0.091	0.011	-0.
C15	-0.285	-0.294	0.036	0.341	-0.004	-0.057	-0.266	-0.010	-0.
C16	0.156	-0.061	-0.135	-0.064	-0.150	0.050	0.258	0.261	-0.

	C10	C11	C12	C13	C14	C15
C11	-0.114					
C12	-0.414	0.356				
C13	0.251	0.012	-0.034			
C14	0.118	-0.085	-0.249	-0.151		

```
C15          0.135  -0.040   0.323   0.256   0.186
C16          0.048  -0.286  -0.168  -0.106   0.002  -0.010

-- COPY M1 C20-C35

-- JOIN C35 C34 C33 C32 C31 C30 C29 C28 C27 C26 C25 C24 C23 C22 C21 C20 C20

-- OMIT ROWS WITH 1.00 IN C20 PUT BACK IN C20

-- HIST C20 -.95 .05

   MIDDLE OF   NUMBER OF
   INTERVAL    OBSERVATIONS
     -0.95          0
     -0.90          0
     -0.85          0
     -0.80          0
     -0.75          0
     -0.70          0
     -0.65          0
     -0.60          0
     -0.55          0
     -0.50          2     **
     -0.45          0
     -0.40          4     ****
     -0.35          2     **
     -0.30          8     ********
     -0.25         12     ************
     -0.20         10     **********
     -0.15         20     ********************
     -0.10         22     **********************
     -0.05         36     ************************************
     -0.00         22     **********************
      0.05         34     ***********************************
      0.10         10     **********
      0.15         14     **************
      0.20         12     ************
      0.25         14     **************
      0.30          8     ********
      0.35         10     **********

-- AVERAGE C20
   AVERAGE =  -0.0036178

   END OF EXECUTION OF STORED INSTRUCTIONS
--

-- REST
```

MINITAB COMMANDS FOR SIMULATIONS

Produces increasing numbers of coin-flipping trials to show how the probabilities associated with binomial events approach a normal distribution as the number of events increases. Final product is a frequency distribution and histogram.

To create the worksheet:
No worksheet is required for this demonstration.

Stored command sequence:

```
NOPRINT
NOTE FLIP A COIN 3 TIMES, RECORD NUMBER OF HEADS
BRAN 1 3 .5 C1
HIST C1
NOTE NOW FLIP COIN 3 TIMES, RECORD NUMBER OF HEADS, REPEAT 10 TIMES
BRAN 10 3 .5 C1
HIST C1
NOTE NOW FLIP COIN 3 TIMES, RECORD NUMBER OF HEADS, REPEAT 25 TIMES
BRAN 25 3 .5 C1
HIST C1
NOTE NOW FLIP COIN 12 TIMES, RECORD NUMBER OF HEADS, REPEAT 25 TIMES.
NOTE SEE HOW DISTRIBUTION BEGINS TO RESEMBLE NORMAL CURVE
BRAN 25 12 .5 C1
HIST C1
NOTE FINALLY, FLIP COIN 20 TIMES, REPEAT 300 TIMES, RECORD NUMBER OF HEADS
BRAN 300 20 .5 C1
HIST C1
```

Only one execution is required to complete this demonstration. The command DESC C1 will provide the mean and standard deviation of the last set of scores. These statistics can be compared to the theoretical mean (10) and standard deviation (.707) of such a distribution.

```
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STORAGE AVAILABLE   5000

-- EXEC

FILE NAME OF STORED COMMNDS?  STAT11.SIM

-- NOPRINT

-- NOTE FLIP A COIN 3 TIMES, RECORD NUMBER OF HEADS

-- BRAN 1 3 .5 C1

   SUMMARY

   VALUE      FREQUENCY
     0          0
     1          1
     2          0
     3          0

-- HIST C1

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
        1.          1     *


-- NOTE NOW FLIP COIN 3 TIMES, RECORD NUMBER OF HEADS, REPEAT 10 TIMES

-- BRAN 10 3 .5 C1

   SUMMARY

   VALUE      FREQUENCY
     0          0
     1          2
     2          5
     3          3

-- HIST C1

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
        1.          2     **
        2.          5     *****
        3.          3     ***


-- NOTE NOW FLIP COIN 3 TIMES, RECORD NUMBER OF HEADS, REPEAT 25 TIMES

-- BRAN 25 3 .5 C1

   SUMMARY

   VALUE      FREQUENCY
     0          4
     1          7
     2         12
```

```
    3        2

-- HIST C1

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
        0.          4     ****
        1.          7     *******
        2.         12     ************
        3.          2     **

-- NOTE NOW FLIP COIN 12 TIMES, RECORD NUMBER OF HEADS, REPEAT 25 TIMES.

-- NOTE SEE HOW DISTRIBUTION BEGINS TO RESEMBLE NORMAL CURVE

-- BRAN 25 12 .5 C1

   SUMMARY

   VALUE      FREQUENCY
     4          2
     5          7
     6          8
     7          4
     8          2
     9          2

-- HIST C1

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
        4.          2     **
        5.          7     *******
        6.          8     ********
        7.          4     ****
        8.          2     **
        9.          2     **

-- NOTE FINALLY, FLIP COIN 20 TIMES, REPEAT 300 TIMES, RECORD NUMBER OF HEADS

-- BRAN 300 20 .5 C1
* DIMENSIONS CHANGED TO   300 ROWS

   SUMMARY

   VALUE      FREQUENCY
     4          2
     5          6
     6          9
     7         23
     8         33
     9         60
    10         57
    11         41
    12         37
    13         21
    14          6
    15          2
```

```
   16        3

-- HIST C1
   EACH * REPRESENTS    2 OBSERVATIONS

   MIDDLE OF    NUMBER OF
   INTERVAL     OBSERVATIONS
        4.            2     *
        5.            6     ***
        6.            9     *****
        7.           23     ************
        8.           33     ****************
        9.           60     ******************************
       10.           57     *****************************
       11.           41     ********************
       12.           37     ******************
       13.           21     ***********
       14.            6     ***
       15.            2     *
       16.            3     **


   END OF EXECUTION OF STORED INSTRUCTIONS
-- REST
```

MINITAB COMMANDS FOR SIMULATIONS

Draws a sample of 50 scores from a population with a mean of 50 and calculates a sample mean after each score is added to the sample. Plots these 50 means against the sample size to show how sample mean approaches the population mean as sample size increases. Demonstrates the law of large numbers.

To create the worksheet:
No worksheet is required for this demonstration.

Stored command sequence:

```
NOPRINT
NOTE - SUPPOSE WE CALCULATE THE MEAN OF A SAMPLE AFTER WE GATHER EACH
NOTE  SCORE. AS THE SAMPLE SIZE INCREASES, THE
NOTE  SAMPLE MEAN WILL APPROACH THE POPULATION MEAN. WE CAN DRAW
NOTE  A GRAPH SHOWING HOW THE SAMPLE MEAN BECOMES MORE ACCURATE AS
NOTE SAMPLE SIZE INCREASES. THE POPULATION MEAN IS 50.
NRAN 100 50 10 C1
PARSUM C1 C2
GENERATE 100 C3
DIVIDE C2 BY C3 PUT IN C4
NAME C4 'MEAN' C3 'N'
PLOT C4 C3
NOTE AFTER 100 SCORES SAMPLED, THE SAMPLE MEAN IS
AVER C1
LET C5 = ABSO (50 - C4)
NAME C5 'ERROR'
NOTE - WE CAN DRAW A GRAPH SHOWING HOW THE DIFFERENCE BETWEEN THE
NOTE  SAMPLE MEAN AND THE POPULATION MEAN DECREASES AS THE SAMPLE
NOTE  MEAN INCREASES>
PLOT C5 C3
```

Only one execution is required to complete this demonstration.

```
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STORAGE AVAILABLE   5000

-- EXECUTE

FILE NAME OF STORED COMMNDS?  STAT12.SIM

-- NOPRINT

-- NOTE - SUPPOSE WE CALCULATE THE MEAN OF A SAMPLE AFTER WE GATHER EACH

-- NOTE  SCORE.  AS THE SAMPLE SIZE INCREASES, THE

-- NOTE  SAMPLE MEAN WILL APPROACH THE POPULATION MEAN.  WE CAN DRAW

-- NOTE  A GRAPH SHOWING HOW THE SAMPLE MEAN BECOMES MORE ACCURATE AS

-- NOTE SAMPLE SIZE INCREASES.  THE POPULATION MEAN IS 50.

-- NRAN 100 50 10 C1

-- PARSUM C1 C2

-- GENERATE 100 C3

-- DIVIDE C2 BY C3 PUT IN C4

-- NAME C4 'MEAN' C3 'N'

-- PLOT C4 C3
```
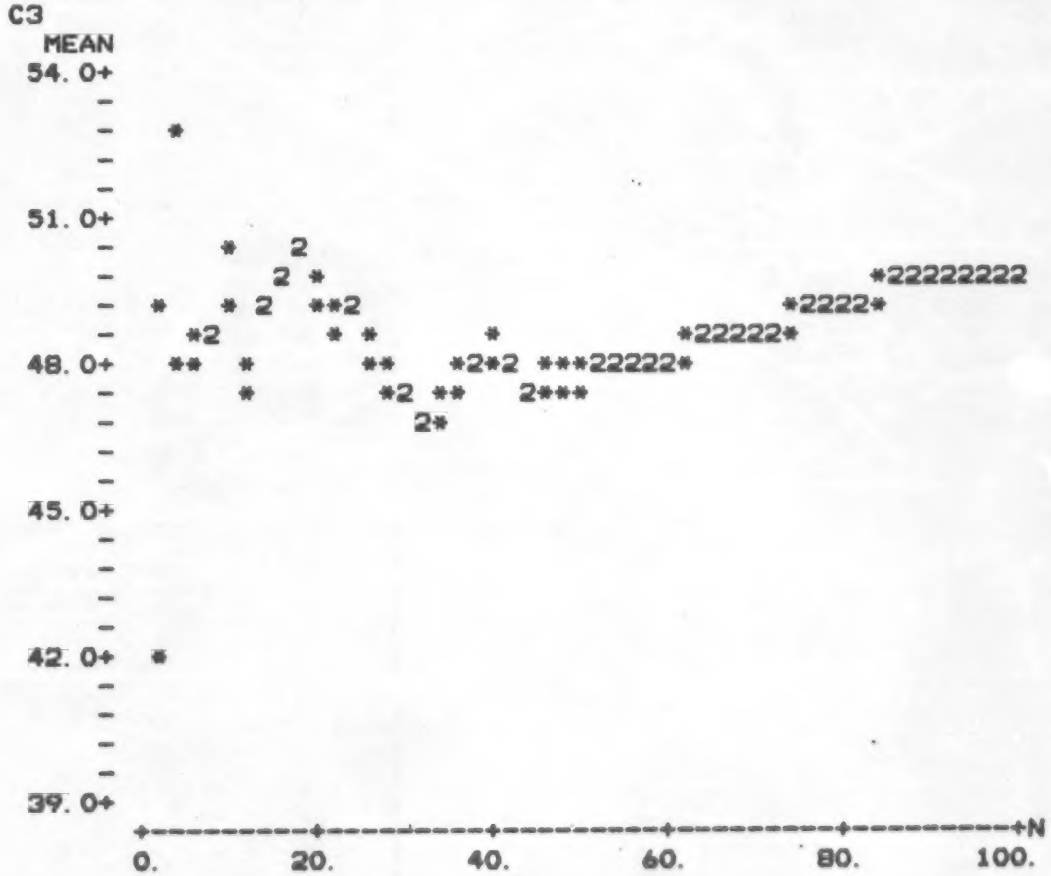
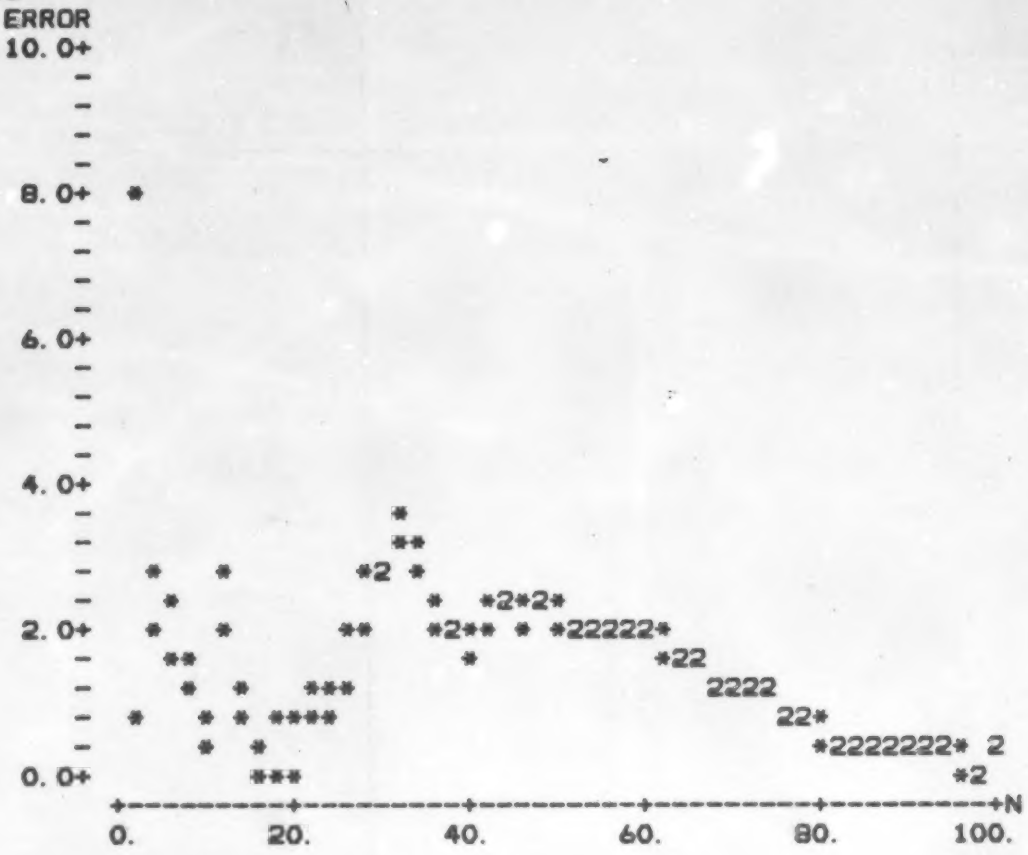



```
-- NOTE AFTER 100 SCORES SAMPLED, THE SAMPLE MEAN IS

-- AVER C1
   AVERAGE =       49.607

-- LET C5 = ABSO (50 - C4)

-- NAME C5 'ERROR'

-- NOTE - WE CAN DRAW A GRAPH SHOWING HOW THE DIFFERENCE BETWEEN THE

-- NOTE  SAMPLE MEAN AND THE POPULATION MEAN DECREASES AS THE SAMPLE

-- NOTE  MEAN INCREASES>

-- PLOT C5 C3
```




```
   END OF EXECUTION OF STORED INSTRUCTIONS
-- REST
```